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INVESTIGATION OF RATE-CONTROLLED SPEECH FOR TRAINING APPLICATIONS

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Two experimental evaluations were conducted to obtain empirical data on the effects of rate-controlled speech variables upon the listening comprehension of Navy trainees using representative Navy training materials.

The results of the first experiment indicated that the intelligibility of rate-controlled recordings produced by a selective deletion device was significantly better than the intelligibility of recordings produced by a systematic deletion device.

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The second experiment demonstrated that both speech rate and content difficulty have a significant, but essentially independent, effect upon listening comprehension. Flesch readability data suggest that the difficulty level of representative Navy training materials is too high for the intended population.

The empirical data presented in the report provide a schematic guide for the application of rate-controlled speech to training content.

SUMMARY

Problem

The Navy needs effective training programs to ensure the maximal utilization of available manpower and to maintain the operational readiness of personnel in the fleet. Efforts to enhance training effectiveness have included increased emphasis upon multimedia approaches and the individualization of training to fit the needs and aptitudes of the learners.

Rate-controlled (compressed) speech appears to be an innovation which can increase instructional effectiveness, but research is needed to identify and evaluate the effects of specific auditory variables upon the listening process.

Background

The present investigation was conducted to evaluate experimentally the effects of two major auditory factors upon the comprehension of speeded speech. Empirical evidence is needed as a basis for developing practical applications of rate-controlled speech to existing or envisioned Navy training programs.

Approach

Two experimental evaluations were conducted using representative Navy subjects and training materials. The first evaluation compared two different methods/devices for speech compression. The second evaluation assessed the interactive effects of compression rate and content difficulty level upon the comprehensibility of auditory training materials.

Results and Conclusions

Comparison of two different devices for compressing speech indicated that the selective deletion method was significantly superior to the systematic deletion method in terms of the listening comprehension scores and the subjective judgments of Navy subjects.

Both the content difficulty level and the rate of speech compression significantly affected the comprehension of auditory training material by Navy subjects. An analysis of variance of the obtained listening comprehension scores showed no significant interaction between the two variables, indicating that the effects of rate and difficulty upon comprehension were essentially independent of each other.

To the extent that the training materials selected for this study are representative, the Flesch readability data suggest that the difficulty levels of Navy training manuals are often too high for the abilities of the intended trainee population.

The empirical data obtained in this investigation provide a preliminary schema for optimizing the rate and the difficulty factors when making practical applications of the auditory mode to Navy training programs. The apparent feasibility of this schema for applying rate-controlled instruction still requires validation in terms of trainee achievement and cost criteria in an operational training context.

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INVESTIGATION OF RATE-CONTROLLED SPEECH FOR TRAINING APPLICATIONS

A. Problem and Purpose

The Navy needs an effective overall training system to maximize the utilization of available manpower and to ensure the operational readiness of personnel in the fleet. Efforts to enhance total training effectiveness have included increased emphasis upon multimedia approaches and greater individualization of training through adaptability of content and method to the needs and abilities of the learner.

The use of rate-controlled (compressed) speech appears to be an innovation which can increase instructional effectiveness and learner acceptability, particularly with individualized and self-study programs. Although speeded auditory presentations have been experimentally employed in a number of training contexts, considerable research is needed to identify and evaluate the effects of specific variables upon the listening process.

This report is concerned with experimental evaluation of two major factors which are involved in the practical application of rate-controlled speech to existing or future training programs. The first of these experimental evaluations was conducted to compare the relative effectiveness of two different methods and devices for producing speeded speech. The second investigation evaluated the interrelationships between increasing degrees of speech compression (speed) and the levels of difficulty of instructional content. The results of these investigations are important, first to provide a basis for selection of the more effective speech compression method/device, and secondly to serve as a basis for the development of a schema which will help ensure optimal matching of audio speeds with content difficulty levels. That is, the experimental results can serve as a basis for the development of a strategy by which rate-controlled auditory presentations can be appropriately applied to different types and levels of training content to maximize instructional effectiveness.

1. Background

Among the alternative instructional methods, the listening mode constitutes a major approach to learning in both formal and informal training contexts. It is generally estimated that over 25 per cent of a person's waking life is spent in consciously listening to spoken language, with relatively lesser portions of time spent in speaking, reading, or writing. A review of the listening research (19), completed as a prerequisite for the current research investigation, indicates the importance of listening in both learning and executing Navy job assignments, and it also notes the relative neglect of training programs designed to improve listening skills. The listening mode offers some unique advantages over other instructional approaches when the trainee group has only marginal reading and vocabulary skills, or when factors in the training environment

(e.g. light, motion) may restrict the utility of visual presentations. Listening ability has generally been found to be less related than reading ability to either intelligence or educational level. A representative military study (17) showed correlations between listening and AFQT scores, and between listening and education to be lower than the respective correlations obtained between reading and either of these same two variables. Listening may, thus, be preferable to reading as a learning mode for many of the trainees within the expected aptitude and educational levels of the all-volunteer manpower force.

For training purposes, listening is readily adaptable to individualized instruction and self-study courses, either as the primary mode or in combination with reading and other instructional modes. Many trainees, because of educational background or individual learning style, may be relatively poor readers and yet be good listeners. The listening mode has already been well integrated into most military and civilian classroom training programs in the form of lectures and other audio presentations. Some individualized audio programs have also been employed in Navy formal schools, such as the Basic Electricity and Electronics Course (15), and in shipboard environments where, for example, they have been used for on-site engine room training (11).

Accelerated or time-compressed speech has certain advantages over normal listening speeds for training purposes. Normal speech delivery is relatively slow in comparison with normal reading rates (100-180 wpm versus 300-500 wpm, respectively), and there is evidence that the brain can process verbal information much more rapidly than is required for listening to unspeeded speech. Initial interest in speech compression research was, in fact, generated partially by efforts to provide auditory information to blind students at a rate most palatable and expedient for them. Numerous research studies (10, 2, 14, 9) have found that the preferred listening rate ranges between 175 and 250 wpm for student and adult samples. The disparity between normal oral presentation rates and potential comprehension rate may cause inattention and loss of interest, with a resultant decrement in overall learning as compared to what might have been learned with more demanding listening rates. Properly utilized, there are also time savings possible through compressed speech presentation which may enhance overall training effectiveness by increasing the total amount of content which can be covered in a given time period or by increasing the opportunities for repetition and review.

The utility of speeded speech has been evaluated in a variety of civilian and military training contexts. Sticht (16) conducted a series of evaluations using Army inductee samples to determine the effects of such variables as AFQT level, signal distortion, degree of compression, and linguistic factors upon the learning of speeded speech materials. At the university level it has been found that students using speeded tapes for academic course material required less tape review time than did students learning from unspeeded tapes for the same material (14). Similarly, it was reported that students in a biology course at a state college saved over 12% in time using compressed recordings with an achievement level equal to that of students using normal recordings in the same

course (13). Speeded audio tapes have also been tried with primary grade students to determine relationships between listening and reading abilities at that level (12). Results indicated a positive relationship between listening comprehension and reading achievement, and an inverse correlation between compression rate and comprehension, somewhat similar to the results obtained for adults. Compressed speech materials were evaluated with both officers and noncommissioned officers in an operational setting at an Air Force academic instructor school (20). In this investigation two sets of experiments confirmed that compressed materials produced as much student learning as traditional lectures. The relative difficulty of the subject matter accounted for large variations in the levels of achievement for these adult samples.

The amount of material which can be effectively learned and retained from speeded speech presentations is, of course, related to a number of learner variables including aptitude, motivation, age, and education. For any given individual, the optimal speech rate for most effective learning depends upon both the method by which the material is compressed and upon the nature of the content of the material to be learned, according to Foulke's comprehensive review of the literature (8).

2. Purpose

The present investigation is concerned with evaluation of both compression method and content factors which influence the comprehensibility of auditory material at the various listening rates. First, an experimental comparison was made between two major methods of speech compression to assess their relative effectiveness in terms of listener comprehension. Secondly, an experimental evaluation was made of the interrelated effects of speech speed and of content difficulty upon listening comprehension. The experiments were designed particularly to obtain needed evidence of the influence of these auditory variables in practical listening contexts which involved representative Navy subjects and appropriate Navy training materials. A detailed description of the methods and results of these two evaluations is contained in the following sections.

B. Comparison of Speech Compression Methods

1. Compressed Speech Devices[1]

The production of intelligible compressed speech recordings requires a method by which the speech rate may be speeded up without appreciably raising the voice pitch in the process. About two decades ago Fairbanks and others (3) developed an electro-mechanical technique which speeded

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[1]Trade names or products are cited herein for purposes of research documentation; this does not constitute endorsement or approval by NPRDC or the Department of the Navy.

speech by systematically deleting portions of the original speech material to produce a time-compressed recording. The Fairbanks-type tape recording devices employ a rotating cylinder with several recording heads equally spaced around it. When the original tape passes over the revolving cylinder, only those portions of the original message which contact the spinning recording heads are retained on the final compressed recording tape. All of the original material which does not contact the recording heads is, thus, systematically deleted in the final shortened version. Most of the previous research on speeded speech has been conducted with Fairbanks-type machines, including the Whirling Dervish, Fairbanks, and Electro-Information Rate Changer. Other more recently developed devices, including Varispeech by Lexicon, and AmBChron, produce compressed speech by systematic deletion involving conversion of the oral material to digital format. Devices by Copycorder and Crown also delete material systematically using an analog method developed by Cambridge Research and Development Corporation.

An alternative approach to speech compression involves selective rather than systematic deletion of the original material. The VoCom machine is representative of this type of electro-mechanical device which compresses speech time by shortening the pauses and the vowel sounds of the original speech passage.

Although not a variable in this study, it may be noted that the foregoing devices are also capable of producing expanded speech. The training benefits of this feature are not as immediately evident as are the time and cost savings and motivational aspects of speeded speech. However, expanded-time presentations may have utility for certain rote learning situations, or for use with disadvantaged trainees.

There are additional methods and devices for speeding speech which involve harmonic alterations or various computerized processes. These are, however, currently less common than the previously described devices.

2. Purpose of Comparison

In accord with many of the previously reported studies by other investigators, the present research investigations were begun using a Fairbanks-type machine to produce compressed speech recordings. The use of similar speech compression machines allows the opportunity for replication or systematic modification of previous research experiments and provides a basis for comparison of obtained results. However, because of the important influence of the method of compression upon comprehensibility, as noted by Foulke (8), a comparison of the alternative methods appeared warranted to ensure that the more effective method would be employed in eventual practical applications to Navy training. Since the long-term objective of these investigations was to maximize the effectiveness of Navy instructional programs through optimization of listening factors, it was important to minimize any loss in comprehension which might be directly caused by the method/device used to compress the speech.

A practical comparison was, therefore, made between the speeded speech recordings produced by two devices representative of the systematic and of the selective deletion methods (Whirling Dervish and VoCom, respectively). The criterion for this comparison was the relative comprehensibility of the recordings as assessed by objective listening comprehension scores and by the subjective judgments of a sample of Navy trainees.

3. Method

The subjects for this experimental comparison were Navy enlisted personnel (N=20) who were in the Code Phase of the Radioman "A" School at the Naval Training Center, San Diego. All subjects fell within the aptitude qualification range for Radioman "A" school and were randomly assigned to one of two equal sample groups for purposes of this experiment.

The speech materials for this experiment consisted of a series of relatively short selections from commercial texts on earth sciences. The materials were selected because they provided a diverse and relatively interesting source of topics presented in a style suitable for oral narration.

The materials were recorded as a series of 40 brief passages at normal speech rate. These passages were then rerecorded on each of the two machines at five different rates of compression (10%, 20%, 30%, 45% and 60% less than original time). A total of 40 questions in multiple-choice format were developed to assess listening comprehension of the passages. On the basis of tryout item difficulty, the 40 passages and corresponding questions were divided into equivalent 20-item halves.

Each subject listened to the two equivalent halves with interruptions for administration of the appropriate test question at the end of each passage. Each subject listened to only one rate of compression but was exposed, in the alternate halves, to both methods of compression (selective and systematic). The test administration was counterbalanced so that all possible combinations of test sequence and compression methods were equally represented. All subjects received preinstruction concerning the general nature of the listening task, but were not given details concerning the two different recording sources. Tests were conducted on an individual basis with each subject requiring about 45 minutes to complete the listening task.

4. Results and Discussion

Table 1 provides a summary of the comparison data in terms of means, standard deviations, and t-value for the significance of difference between the mean scores for the two speech compression devices.

The difference between the listening comprehension mean scores for the two compression methods was highly significant in favor of the selective method as indicated by the tabled t-value. The significantly better comprehensibility of the selective recording as revealed by the resultant

TABLE 1

Comparison of Listening Comprehension Scores for Two Methods of Speech Time-Compression

Method	N	Mean Score	Standard Deviation	Difference Between Means	t-value	Significance Level
Selective	10	7.8	2.3			
				2.5	3.38	<.005
Systematic	10	5.3	2.3			

scores was also generally supported by the subjective opinions of the subjects who expressed listening preference for the selective compression portions of the audio narrative. In evaluating the audible differences between the two sample types of recordings, it appeared that the relatively lower interruption rate and consequent reduced "echo" effect of the selective recording accounted, in part, for the improved intelligibility of the recording, particularly at higher compression rates.

Despite certain advantages to be gained in using Fairbanks-type machines with respect to maintaining comparability with previously published research, the results of this experimental comparison indicated the desirability of using the selective compression machine for ensuing speeded-speech experimentation to ensure the intelligibility of the recordings. The selective compression device does have some additional minor advantages over several current machines with respect to relative simplicity of operation and lower initial purchase cost. There is little doubt that speech compression devices will continue to improve in quality and utility with future advances in technology in this area. Thus, whatever the levels of listening comprehension achieved using present machines, the levels should at least be duplicated or surpassed when using future devices having enhanced capabilities.

C. Evaluation of Effects of Speech Rate and Content Difficulty

1. Background

Listening comprehension is directly affected by both the rate at which audio material is presented and by the level of difficulty of the content material. There have been many investigations (10, 2, 14, 9, 7) which have studied the effects of increasing speech rates upon listening, usually with the variable of content difficulty held constant across rate changes.

Likewise, investigations have been made of the effects of content difficulty and topic area upon listening comprehension (17, 20), but in these investigations the speech rate has generally been maintained constant across the various levels of content difficulty. Level of content difficulty in these studies has usually been assessed by a readability formula, since Sticht and others (17) have reported that for practical purposes measures of readability can serve as measures of listenability. There are relatively few examples of studies (4, 18) which have been concerned with the combined effects of concurrent increases in speech rates and content difficulty upon listening comprehension. In particular there is a lack of evidence from any studies using appropriate Navy training materials and representative subjects. In general, the more relevant evidence has shown that as either speech rate or content difficulty rises, the comprehensibility of the aurally presented material decreases. In a manner somewhat similar to the reading process, however, if the speech rate is too slow, or if the material is too simple, the auditory presentation may not be sufficiently demanding to maintain the listener's attention or motivation. Between the extremely low or extremely high levels of auditory rate and difficulty there apparently are levels which are optimal in terms of yielding maximum amount of listening comprehension while requiring minimal presentation time and redundancy.

In order to make meaningful applications of speeded speech technology to training programs, it is necessary to have empirical data, from experiments with representative training materials and subjects, which will indicate the degree of listening comprehension which can be expected for each of the various levels of content difficulty at each of the various presentation rates. These data are needed to ensure that in any given training program application the optimal listening comprehension levels are maintained through consideration of the combined influence of speech speed and difficulty levels. For example, in applying the listening mode to existing training programs, the rate of presentation can be appropriately adjusted to best match the difficulty levels of the instructional content. Or, if the training content is amenable to modification, the verbal level of the course may be simplified by rewriting in order that the listening rate may be increased while still maintaining the desired comprehension level. Of course, exact specification of levels for each of these listening variables, and decisions regarding the feasibility of tradeoffs between the amount of trainee comprehension and the required presentation time would necessarily be made on the basis of actual training tryouts and in accord with the instructional goals of the individual programs. The present experiment is primarily intended to provide initial insights and empirical results to aid in the development of a general schema for maximizing the effectiveness of auditory applications to practical Navy training situations.

2. Method

The following general procedures were employed in experimentally evaluating the relative effects of the two variables of content difficulty and speech rate upon listening comprehension.

The experiment was set up as a 5 X 5 repeated measures analysis of variance design, with content difficulty and speech rate representing the two factors with each factor having five different condition levels. With this repeated measures design the same group of subjects is observed under more than one treatment condition. In this instance, each of the five subject groups was successively tested with five different levels of content difficulty, all presented at the single speech rate to which the group was assigned.

The subjects were, as in the previous experiment, Navy enlisted personnel (N=50) who were in the Code Phase at the Radioman "A" School. All subjects fell within the aptitude qualification range for Radioman "A" School and were graduates of that training course. Subjects were arbitrarily assigned to one of the five treatment groups of ten subjects each.

The training materials employed were selected from the Basic Military Requirements rate training manual (1) which was chosen as a representative and widely used example of training content for Navy enlisted personnel. Material was taken from two chapters, (I & XIX) which appeared to be the least abstruse or specialized in terms of topics and vocabulary and which did not involve numerous reference charts, tables, or diagrams. The difficulty levels of the material were assessed by using a modified version (5) of the Flesch readability formula (6). A total of ten passages were selected from the manual and grouped into five levels of difficulty on the basis of assessed readability scores. Two separate passages, having equal readability scores but taken from two different chapters, were paired to represent each of the five levels of content difficulty. The combined Flesch readability scores, in order of increasing levels of difficulty were 78, 63, 52, 34, and 20. These values roughly represent school reading grade equivalents of 7th, 8th, high school, college, and college graduate, respectively.

The audio passages were prepared for this study by having them recorded on tape at an original speed of approximately 175 wpm. They were then rerecorded on the selective type speech compressor at compression rates of 15%, 30%, 45%, and 60% to provide a total of five different speech rates, including normal, approximating 175, 206, 250, 318, and 437 words per minute, respectively.

A cloze test was developed for each of the narrative passages to serve as a measure of listening comprehensibility for the audio presentations. The cloze technique, which has been widely employed for this purpose in previous studies, consists of deleting every fifth word and inserting a uniform blank space in a printed replication of each oral passage. The listeners, after hearing each passage, are required to fill in the blanks with the exact missing word or homonym. Correct words which are misspelled are counted as correct, but synonyms are not. The cloze tests comprised a total of 80 possible responses for each subject. Since each level of difficulty was represented by two equivalent passages, the paired cloze test scores were combined to yield a single possible score total of 16 at each of the five levels.

Testing was conducted separately for each of the five subject groups. Each group, after a brief orientation period, was administered the audio passages in the same order of content difficulty, from least to most difficult, at the constant speech rate designated for the group. After hearing each passage, the corresponding cloze test was immediately received and completed by the subjects. Each experimental group required about 50 minutes for listening and testing on all passages. Experimental testing of all groups was accomplished in a single day.

3. Results and Discussion

Table 2 provides the results of the analysis of variance of the cloze test scores obtained by the sample groups under the experimental treatments involving speech rate and content difficulty factors.

TABLE 2

Analysis of Variance for Test Data From
Compression Rate x Difficulty Level Experiment

Source	df	Mean Square	F	Significance Level
Between Subjects				
Compression (A)	4	40.59	3.28	<.02
Error	45	12.37		
Within Subjects				
Difficulty (B)	4	56.63	21.97	<.001
A x B	16	3.82	1.41	ns
Error	180	2.70		

The analysis presented in Table 2 indicates that both factors, compression rate and difficulty level, significantly affect the level of listening comprehension as measured by cloze tests. The difficulty factor had, relatively speaking, a much more significant influence upon comprehensibility. There was no significant interaction found between rate and difficulty level indicating that the effects of these two variables were essentially independent of each other. Estimation of the effects of these factors upon comprehension is, thus, simplified since the effects of either of the two variables may be estimated without regard to the treatment level of the other.

The actual cloze test scores obtained by subject groups under each of the treatment conditions are presented in Table 3. These data provide a clearer indication of the nature of the interrelationships among variables which accounted for the analysis of variance results presented in the previous table. Although individual cell entries are not particularly informative, inspection of the score trends across cells gives a general overview of factor influence at different treatment levels.

The test score entries in Table 3, despite some anomalies in the linear pattern, confirm the general influence of increasing rate and difficulty upon listening comprehension. When contrasting the extreme levels of the two factors, it is particularly evident that comprehensibility was reduced by both high speech rates and content difficulty. In accord with the relative magnitude of the obtained significance values for the two factors, it is apparent that the factor of content difficulty had a relatively major impact on comprehension. That is, even at normal listening rates, the test scores on high difficulty material are lower than the scores on easier material presented at 60% compression rate. Although the comprehension test scores for all subject groups are maintained fairly well through the first three levels of content difficulty (7th grade through high school) they drop off noticeably when difficulty reaches college levels. Conversely, it appears that listening comprehension was only slightly affected by increasing speech rates through 30% compression (approximately 250 wpm), and that reasonable comprehensibility was maintained at even the highest speech rate with the least difficult materials.

Because of the evident importance of the difficulty factor in auditory comprehension, it appears that in any practical attempts to apply speeded speech to training programs a primary concern should be the initial listenability level of the training materials. In this regard, an interesting, but subsidiary, finding was noted during the process of selecting passages from the Basic Military Requirements manual. In order to determine the content difficulty levels, many sections of the manual were assessed by the Flesch readability formula. In general, the reading grade level requirements of the material were found to be quite high throughout, considering that the manual is intended to serve as a self-study training course for Navy pay grades E-2 and E-3. As an example, two chapters which were considered for selection (Chapters VIII, XVIII) yielded Flesch readability scores of 45 and 49, respectively, on the basis of a complete word-by-word count. Since Flesch scores of 50 or less indicate college level readability, both of these chapters are, on the average, above the reading level expected for high school graduates. This is not to indicate that this manual, in particular, is poorly written. Rather, the manual probably compares favorably with most other military and civilian training manuals of its type. The difficulty in preparing training manuals that present material at the appropriate reading level represents a common training problem which has long been resistant to corrective action. The findings do serve as a cautionary note with respect to the prerequisite need to determine that the difficulty level of training materials is suitable for the target population, regardless of the eventual choice of presentational mode.

TABLE 3

Total Test Scores for Subject Groups in Listening Rate x Difficulty Experiment

Compression Rate	Group	N	Content Difficulty (Approximate Grade Levels) 7th	8th	H.S.	Coll	Grad	TOTAL
0%	I	10	102	107	104	87	80	480
15%	II	10	108	97	102	91	74	472
30%	III	10	102	97	106	77	80	462
45%	IV	10	88	68	93	72	68	389
60%	V	10	92	82	77	70	69	390
TOTAL		50	492	451	482	397	371	2193

D. Summary and Conclusions

The present study is part of a continuing research effort to enhance training effectiveness through application of innovative instructional methods, specifically including rate-controlled speech. Two related experiments were conducted to obtain empirical data on the effects of auditory variables, using representative Navy trainees and typical Navy training content. The first experiment compared the relative effectiveness of two different methods of speech compression. The second experiment evaluated the effects of two variables, content difficulty and speech rate, upon the comprehensibility of auditory material.

For the first experiment, a Fairbanks-type speech compression device was compared with another speech compression device which changes rate by selective rather than systematic deletion of audio passages. On the basis of listening comprehension scores achieved by Navy subjects the intelligibility of recordings produced by the selective deletion device was demonstrated to be significantly higher.

In the second experiment, audio passages at five predetermined difficulty levels were presented at five different compression rates to five groups of Navy subjects. An analysis of variance of the resultant listening comprehension scores for the experimental groups showed both the speech rate and the content difficulty variables to have a significant influence, with the significance level relatively much higher for the difficulty factor than for rate. There was no statistically significant interaction between the two variables, indicating that the main effects of rate and difficulty operated essentially independently.

With regard to the relative importance of content difficulty upon listening comprehension, it was noted that much of the content of the Navy manual used as a text source for this experiment was written at a level which is generally too demanding for the intended trainee users. Flesch readability scores which were assessed for several complete chapters indicate that the reading ability requirements for the text were above the entering college grade level. This particular training manual is probably representative of the majority of the military training materials in terms of levels of readability. The findings, therefore, serve to reemphasize the importance of ensuring the original comprehensibility of training materials before any attempts are made to enhance their instructional effectiveness through varied presentational approaches. This is particularly true of application of either normal or speeded audio instruction, since the experimental data of this study confirm the direct effects of content difficulty upon listening comprehension at all speech rates.

In summary, the two experiments described herein provide empirical data concerning the interrelated effects of auditory variables upon the listening comprehension of groups of Navy subjects using typical training materials. The relative superiority of the selective deletion method for producing compressed speech was demonstrated by the first experiment.

The second experiment demonstrated the significant effects of both speech rate and content difficulty upon comprehension, and provided a matrix of listening comprehension scores obtained by subject groups at each of the treatment levels of rate and difficulty. The data in this matrix serve as a schematic guide for application of rate-controlled speech to training content. That is, for any given training program the audio rate can be selected and applied in accordance with the assessed difficulty level of the content in order to ensure that the desired degree of listening comprehension is maintained. Similarly, in instances where the content difficulty level can be modified by revision and simplification, estimates may be made of the level to which speech rate can be increased without adversely affecting the expected degree of listening comprehension. Since the experimental data showed no significant interaction between the two main variables, the expected listening comprehension values may be considered as a simple function of the independent effects of rate and difficulty regardless of treatment level.

To the extent that the selected training manual is representative of Navy instructional materials for enlisted personnel, the Flesch readability data suggest that the initial difficulty level of many training materials may be too high for the intended population, even when presented at normal speech rates.

The proposed approach for optimization of the rate and difficulty factors in auditory instruction should be facilitated by the empirical results presented in this study. The apparent feasibility of this listening application strategy still requires validation in terms of trainee achievement, time and cost savings, learner acceptability, and other relevant criteria assessed in an operational training criteria context.

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